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THE DESIGN OF AN INTERACTIVE  
COMPUTER BASED SYSTEM FOR THE  
TRAINING OF SIGNAL CORPS OFFICERS  
IN COMMUNICATIONS NETWORK MANAGEMENT

THESIS

Max N. Hall  
Captain, United States Army

AFIT/GE/ENG/85S-2

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FOR THE TRAINING OF SIGNAL CORPS OFFICERS IN  
COMMUNICATIONS NETWORK MANAGEMENT

THESIS

Presented to the Faculty of the School of Engineering  
of the Air Force Institute of Technology  
Air University  
In Partial Fulfillment of the  
Requirements for the Degree of  
Master of Science in Electrical Engineering

Max N. Hall, B.S.  
Captain, United States Army

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Abstract

This research effort makes a recommendation for the hardware design of a microcomputer based simulation system for the training of US Army Signal Corps officers in communications network management. In order to do this, the first step was to establish the requirements for communications network management in a Signal Battalion S-3 section, and based upon these requirements, establish the criteria for the simulation system.

Once the criteria were established, several computer systems currently in use in the Armed Forces as simulators or as decision making aids, were rated against the criteria. Because of these ratings, the Army Tactical Frequency Engineering System (ATFES), with the Tower microcomputer, was selected for further study as the system the simulator design would be based upon.

The system designed consisted of two networked Tower microcomputers, with the persons being trained using one, and the exercise controllers using the second. As a result of the this design, the personnel being trained appear to be in an actual operations environment, and do not have any direct contact with the computer simulations. All simulations are given to the students through the controllers. In this manner, the realism is increased for the students, and a more effective training environment is established.

## I. Introduction

### Background

The tactical army of the 1980's has become increasingly dependent on the communications network which supports it. Not only are standard forms of communications such as voice and teletype being used, but now facsimile and data (computer) transmissions are used with great regularity. Equipment is also changing to meet this increased communications flow. Along with AM, FM, and Multichannel Radio systems, satellite communications and automatic digital switchboards are increasingly integrated into the overall communications network. Because of the weapons systems currently available to our potential enemy, our tactical forces are becoming more mobile, and as a result of this, the supporting communications system must also increase its mobility. In addition to signal centers moving more often, Mobile Subscriber Equipment (MSE) will be introduced in the late 1980s allowing tactical leaders to tie into the backbone multichannel system while they are on the move, thus making for an even more fluid battlefield.

All of these changes have made the tactical communications networks at Corps and Division level increasingly complex and more difficult to manage. Signal Battalion S-3 (operations) officers can no longer manage and troubleshoot these networks out of the back of a jeep while driving from site to site. They must be able to implement, maintain, and modify the system at a rapid pace. Crises need

to be handled quickly while not ignoring the entire Corps or Division network.

In spite of these increased management needs, the Signal Corps only has a limited program for the training of potential operations officers in systems and network management. At the Signal Officer Basic Course (SOBC), the 792 hours of training for new Lieutenants are distributed as follows:

<u>SUBJECT AREA</u>	<u>% TIME SPENT</u>	
Leadership skills	19%	
Communications-Electronics Technology	26%	
Combat Operations (Tactics)	10%	
Combat Communications	18%	
Supply/Organizational Maintenance	10%	
Other	17%	(1:4).

All systems management work takes place during the combat communications training. Approximately one half of this time is spent on a Field Training Exercise (FTX), while the rest is classroom work with none of the pressures of actually installing systems.

At the Signal Officers Advanced Course (SOAC), Captains are trained for company command, and Signal battalion or brigade staff. The 800 hours of training are distributed as follows:

<u>SUBJECT AREA</u>	<u>% TIME SPENT</u>	
Leadership skills	12%	
Communications-Electronics Technology	24%	
Combat Operations (Tactics)	11%	
Combat Communications	20%	
Supply/Organizational Maintenance	09%	
Other	24%	(2:3).

Again systems training takes place during the combat communications phase where approximately 50% of the time is spent on the planning of Corps and Division exercises. However, this is strictly classroom time and there is no field training at all. Less than 1% of the training time is spent on multichannel systems troubleshooting during the course of instruction.

Once the officer is with his unit, the only training generally received is during actual field problems when he must perform his job (whether as a platoon leader, company commander, S-3 etc). He must, in effect, learn systems operations on his own. In addition, it is impractical to move an entire Signal Battalion to the field just to train the staff. The cost in manpower, maintenance, and fuel would be enormous, no matter how much experience the staff gained.

The combat arms have a similar problem in that they must train their officers in tactical operations. While most basic soldiering skills can be taught through training, there has always been the more difficult task of training the commander and his staff in the making of critical decisions under battlefield conditions. This training has been completed over the years by three traditional methods. The first of these is the use of FTX's. While this is the best method for training officers, there are several disadvantages which prevent this from being the sole method of training. Chief among these are equipment damage, personnel injuries, and high cost (3:2).

The second method of training leaders is the Command Post Exercise (CPX). In a CPX only the commander and his staff move to the field and maneuver. However, there are again the problems of equipment damage, injury, and high cost. Additionally, an unreasonable time separation between the commander and his unit occurs which prohibits the excessive use of CPX's.

The third technique is to plan and conduct combat training on terrain board war games. In these board games, commanders and staff move miniature representations of units and equipment over a map board. There are a series of rules and probability tables which govern tactical engagements with other units. While this method is relatively inexpensive, there are other problems. These include a lack of reality, size limitations, and becoming overly familiar with the terrain if the system is used frequently (3:3).

As a result of the shortcomings in all of these training methods, the Army began researching the use of automation in training. In 1971 a set of requirements for an automated CPX were developed, and in 1973 the design of a prototype system was begun (4:1). In 1976, the first automated combat management trainer was fielded. This system was called the Combined Arms Tactical Training Simulator (CATTS), and simulated the engagement of a US Army battalion and a Soviet motorized rifle regiment. A mainframe computer was used to support this system (4:1-2).

Since 1976, research has continued at two different levels. First, the follow up research to CATTS was the

implementation of the CATTS system with minicomputer technology, and an expansion of the database used in the original CATTS. In 1983 a prototype simulator called the Army Training Battle Simulation System (ARTBASS) was developed by Singer Corporation and after extensive testing, the Army has decided to start fielding the system in the fall of 1985 (5:1).

The second area of research began in 1980 and was concerned with the development of a microcomputer based simulation system. In 1982 a system called MACE (not an acronym) was fielded which was based upon networked Apple II computers. While prototypes have been developed for Ft Lewis, Washington and Ft Leavenworth, Kansas, the system is still in a testbed mode and is undergoing revision (6:2).

The combat arms have continued the development of these simulators so that now commanders can gain the experience of moving about the battlefield, engaging the enemy, and in general performing the same functions that would be required in a FTX environment, without the associated costs. In addition, different scenarios can easily be implemented and tried so the officer can see what would happen if he tried a different alternative in a particular situation. Other problems, to include administration, logistics, weather and Nuclear, Biological and Chemical (NBC) effects can all be inputs to scenarios. Obviously, the potential for learning is great, while the relative cost is low (5,6).

To date, the Signal Corps has not developed either a terrain board or computer based "wargame" to train its officers. In addition, the simulators developed for the combat arms, do not address the unique problems which face the Signal Corps officer as he tries to manage the communications network.

#### Problem

The problem was to find a method of training Signal Corps officers in communications network management which would not only be relatively inexpensive, but would also provide the realism needed to be effective training.

#### Scope and General Approach

The research objective was to complete a system level hardware design for an interactive computer based training system. This system was to be used to train United States Army Signal Corps officers in the planning, installation, operation, and maintenance of tactical communications networks.

In order to reach this objective, the approach was broken into three general areas: establishing the criteria; identifying potential systems; and selecting a system for further research and modification. First was the need to establish the criteria required of a system for the training of Signal Corps officers in communications network management. This was accomplished by completing a literature search of military training and operations documents (see Appendix A) in order to establish the general duties of the

operations section of a signal battalion. Based upon these duties, the criteria for the Signal Corps Interactive Training (SCIT) system were established.

Next, a second literature search was completed in order to identify military computer based training systems currently in operation which would have a potential for use by the Signal Corps. Once these systems were identified, in depth research was completed on each, and when possible, they were visited. Each system was then rated against the criteria established for the SCIT system.

Finally, based upon the ratings completed in the second step, the system which most clearly matched the initial criteria was selected for further research and modification. This selection and subsequent modification resulted in the hardware design submitted as the final result of this research project.

#### Assumptions

In working on this thesis there were several assumptions made at the start. First, it was assumed that either a minicomputer, a microcomputer, or a network of microcomputers would be the basis for the system design. Mainframes were not considered because of cost and because of the relatively high computing power now available in minis and micros.

Second, the design was not communications equipment specific due to the uncertainty of what type of MSE equipment would be selected for implementation in the 1986-88 time frame. The decision on what type of MSE equipment would

be used, was made in the summer of 1985 and the results were not known soon enough to be used in this thesis effort.

Finally, it was assumed that a system would not have to be designed from inception. Because of the preponderance of systems already available in the military and civilian communities, it was felt that a suitable system could be found and modified to suit the needs of the Signal Corps.

#### Summary of Current Knowledge

While there are several tactical simulators in operation, knowledge of the modeling or simulation of communications systems is limited. Simulation work had been completed with success at the communications equipment operator level as early as 1981 and was being used at Ft Gordon in the Reactive Electronic Equipment Simulator (REES) system (7,8). This minicomputer controlled system allowed a controller to place equipment failures on mock communications equipment and the operator would then attempt to troubleshoot the system. However, no provisions were made to expand this system to allow for the training of officers on total systems management.

Some modeling of communications networks had also been previously completed. In 1976, the tactical communications networks in Europe were modeled in a system called TACNET. This system was used primarily for the purpose of statistically modeling the degradation of the overall communications network and did not allow for any operational input at the lower tactical planning levels (9). Again, there

were no provisions for the inclusion of officer training or interaction in network management.

As a result of this lack of communications management simulation, a great deal of the research effort in this thesis centered on the evaluation of tactical combat simulators and computers used in systems management. These systems will be covered in chapter two.

### Organization

Chapter two of this thesis covers two areas. First, the evaluation criteria are established and weighted, and secondly, an overview of each system being evaluated is given. In chapter three, each system is evaluated against the established criteria and the results of the evaluations are given. Based upon these evaluations, a best system was selected. Chapter four then gives a complete listing of the capabilities of the selected system and establishes the final recommended design for the SCIT system. Recommendations and conclusions are presented in chapter 5.

## II. Background

### Introduction

This chapter is divided into two parts. The first gives the requirements for communications network management in a Signal Battalion S-3 section and based on these requirements, the criteria for the SCIT system are established. The second section gives an overview of the computer based systems to be evaluated against the criteria established in the first section. These systems include tactical simulators currently in operation or development and other computer based systems which are currently being used in field operations.

### Establishing the Criteria

In establishing the requirements for the SCIT system, a literature search was completed in order to outline what the general guidance for a Signal Battalion operations section was. This guidance is not contained in any one book or manual, but is spread among several manuals. Appendix A contains the results of this search and divides the requirements by specific tasks into four general areas. These areas are: planning, engineering, maintaining/controlling and records/reports. These tasks are translated into systems criteria in the subsequent section titled Operations Requirements. In addition, there are other requirements which address the physical characteristics of the system. These are outlined in the section titled Physical

Requirements. Finally, there is a section which establishes the weighting of the criteria outlined in the systems and physical requirements sections.

#### Operations Requirements.

Planning. During the planning phase of an operation the S-3 must complete the following tasks:

1. Determine personnel and equipment requirements.
2. Plan the communications network (to include site locations).
3. Plan traffic routes.
4. Allocate circuits.
5. Maintain a system of priorities.
6. Assign assets and responsibilities.
7. Prepare and disseminate directives via Operations Orders (Opords).

After receiving an Opord from higher headquarters, the S-3 section would determine personnel and equipment requirements based on the mission received. No specific SCIT system capabilities are needed to meet this requirement. For requirements two through six, while no system capabilities are needed to make the required decisions, a separate database would be needed for each requirement so that once the appropriate decisions were made, the information could be recorded for future use. It should also be noted that requirement two requires access to terrain elevation information.

When preparing directives (requirement seven), in addition to written instructions, signal Opords also include systems diagrams, circuit routing charts, site locations, frequency allocations, etc. This information should be obtainable from the databases needed for requirements two

through six. So, an additional requirement is that the database information be printable in Opord format.

Engineering. During the engineering phase of an operation, the S-3 must complete the following tasks:

1. Supervise activation of the system.
2. Transmission link activation.
3. Supervise and coordinate the installation of the communications system.
4. Frequency management.

Requirements one through three are closely related, as all of them involve systems installation. These requirements must be implemented on the SCIT system using a simulation capability. Tactical communications systems are rarely installed without some type of problem that must be overcome. While solutions are usually found at the operator level, this is not always the case. These more difficult problems would need to be simulated, which the S-3 section would then need to troubleshoot and correct.

Requirement four would require access to a database if interference problems are to be included in the simulation. This would allow new frequencies to be employed if needed to resolve interference problems.

Maintain/Control. During the maintain/control phase of an operation, the S-3 must complete the following tasks:

1. Change the existing communications network due to:
  - a. Signal Center displacement or destruction.
  - b. Route Changes.
  - c. System or circuit outages.
  - d. Changes in the tactical situation which would cause:
    - 1). Reallocation of resources.
    - 2). Redeployment of MSE resources.
2. Maintain a continual tactical update.
3. Trunking management.

This phase is similar to the engineering phase in many ways. All requirements must be met through the use of the simulation of problems within the communications system. In addition, the S-3 section will need to make continual changes to the databases, dependent upon changes made to the network.

Records/Reports. There are a number of records and reports which the S-3 section must maintain or report to higher headquarters. These include:

- |                       |   |
|-----------------------|---|
| 1. Opords             | 7. Traffic volume records.              |
| 2. Frag Orders.       | 8. Equipment status records.            |
| 3. NBC reports.       | 9. Equipment performance records.       |
| 4. Personnel reports. | 10. System and circuit quality records. |
| 5. Circuit records.   | 11. Critical events log.                |
| 6. Systems records.   |   |

All of these records or reports may be maintained in the form of separate databases.

Conclusion. In summary, the requirements for the S-3 section translate into the following SCIT system criteria.

1. A signal database capability.
2. A simulation capability.
3. Use of wordprocessing software.
4. Use of a map terrain elevation database.
5. A Records and Reports database capability.

Physical Requirements. This section contains those additional system requirements which relate to actual hardware criteria. Each requirement is listed along with a short description of how comparisons were made between systems.

Speed. Speed is important for keeping user wait time to a minimum. Since there was no piece of software available to test the speed of all systems, comparisons were

made based on processor clock speeds, and on any hardware enhancements which improved the overall speed of the system.

Expandability. Expandability in this context means addressing the capability of the system to expand in the future as new technologies or capabilities become available, without requiring the system to be completely replaced. It also addresses the capability of increasing the number of users on the system.

Networking Capability. Networking capability addresses the ability of the system to have more than one user on the system at a time and the capability of the system to use multiprocessing through networking.

Software Capabilities. Several criteria were considered for the current software capabilities of the system. First, was the graphics capability of the system. Graphics capability addresses the ability of the system to present both on screen and printer graphics. These are needed as a minimum for map overlays of unit locations and line of site presentations.

Next, commercial software availability was evaluated by the amount and types of commercial software already included with the system. Finally, all systems were evaluated to determine what current simulation capabilities they had. If a simulation capability existed, it was evaluated for realism and timeliness.

Input/Output (I/O) Capability. The I/O capability of each system was measured by the types of input and output devices available with the system. User friendliness of I/O devices was also taken into account.

Cost. Cost was considered by comparing total systems cost as they currently exist.

Memory Capabilities. Memory was considered in several different ways, to include internal, on line, off line, and map storage. Internal memory was considered since in general, a larger internal memory reduces the time spent by the system on memory fetches. Memory was compared based upon total internal system storage capabilities.

On line memory addresses the size of the virtual memory available to the system through the use of floppy disks, hard disks, or tape capabilities.

Off line memory addresses the manner of backup storage used by the system, including convenience of use.

Map storage was considered as a separate area of interest from the storage of terrain elevation data. Map storage here means the capability of the system to bring a section of map to the video screen to be viewed in a manner similar to a conventional map.

Security Capability. Each system was evaluated for its security capability. This included prevention of unauthorized access, prevention of a tempest hazard and any other security measures which had been taken.

Conclusion. In summation, the physical criteria used to evaluate the systems were:

- |                           |                                       |
|---------------------------|---------------------------------------|
| 1. Speed.                 | 8. Map storage.                       |
| 2. Expandability.         | 9. On line memory.                    |
| 3. Networking capability. | 10. Off line memory.                  |
| 4. Graphics capability.   | 11. Commercial software availability. |
| 5. I/O capability.        | 12. Other simulation capability.      |
| 6. Cost.                  | 13. Security capability.              |
| 7. Internal memory.       |                                       |

Criteria Ranking and Weighting. In order to establish the importance of each of the criteria in ranking the potential systems, a listing of the established operations and physical criteria was given to each of the following personnel:

LTC Bowser: Thesis sponsor.	MAJ Zapka: Thesis reader.
CPT Woffinden: Thesis advisor.	CPT Hall: Thesis student.

Each person was asked to rank order these criteria in order of importance. The results of these rankings are displayed in Table I.

TABLE I  
RANK ORDERING OF CRITERIA BY INDIVIDUAL RATINGS

<u>CRITERIA</u>	<u>LTC BOWSER</u>	<u>CPT HALL</u>	<u>MAJ ZAPKA</u>	<u>CPT WOFFINDEN</u>
SPEED:	2	3	4	4
EXPANDABILITY:	7	1	2	5
NETWORKING CAPABILITY:	10	2	3	2
DIGITAL TERRAIN CAPABILITY:	6	4	6	7
GRAPHICS CAPABILITY:	8	5	5	6
INPUT/OUTPUT CAPABILITIES:	1	11	12	3
COST:	15	10	1	1
INTERNAL MEMORY:	3	8	9	9
MAP STORAGE:	5	6	8	12
ON LINE MEMORY:	4	9	10	10
SIGNAL DATABASE SOFTWARE:	13	7	7	8
OFF LINE MEMORY:	9	12	11	11
COMMERCIAL SOFTWARE AVAILABILITY:	12	13	13	14
OTHER SIMULATION SOFTWARE CAPABILITY:	14	14	14	13
SECURITY CAPABILITY:	11	15	15	15

It should be noted that LTC Bowser (the thesis sponsor), rated cost last. For this reason, cost was removed as a criteria in subsequent weighting decisions. From Table I, three different ranking schemes were computed for use in comparing the systems being evaluated. The first ranking is a "users" ranking and is dependent only on LTC Bowser's rankings. The second ranking is an "engineers'" ranking and is based on the averaged rating of CPT Woffinden, who has a masters degree in computer science; MAJ Zapka, who has a masters degree in electrical engineering; and CPT Hall, who is working towards a masters degree in electrical engineering. The final ranking is the average of the four individual rankings. Additional information on the statistics of these average weightings may be found in Appendix B.

For each of the ranking methods, the individual criteria were given a value weight of between 1 (low) and 14 (high). This weight was given based upon the criteria's rating within that particular ranking method. The criteria rated first was given a weight of 14; the criteria rated second was given a weight of 13; and so on down to the criteria rated fourteenth, which was given a weight of 1. A summary of these separate rankings and their subsequent criteria weightings are given in Table II.

TABLE II

## CRITERIA RANKING SCHEMES AND THEIR RESPECTIVE WEIGHTINGS

<u>CRITERIA</u>	<u>USER RANK</u>	<u>USER WEIGHT</u>	<u>ENGI- NEER RANK</u>	<u>ENGI- NEER WEIGHT</u>	<u>GROUP RANK</u>	<u>GROUP WEIGHT</u>
SPEED:	2	13	3	12	1	14
EXPANDABILITY:	7	8	2	13	2	13
NETWORKING CAPABILITY:	10	5	1	14	3	12
DIGITAL TERRAIN CAPABILITY:	6	9	5	10	4	11
GRAPHICS CAPABILITY:	8	7	4	11	5	10
INPUT/OUTPUT CAPABILITIES:	1	14	7	8	6	9
COST:	15	-----				
INTERNAL MEMORY:	3	12	8	7	7	8
MAP STORAGE:	5	10	9	6	8	7
ON LINE MEMORY:	4	11	10	5	9	6
SIGNAL DATABASE SOFTWARE:	13	2	6	9	10	5
OFF LINE MEMORY:	9	6	11	4	11	4
COMMERCIAL SOFTWARE AVAILABILITY:	12	3	12	3	12	3
OTHER SIMULATION SOFTWARE CAPABILITY:	14	1	13	2	13	2
SECURITY CAPABILITY:	11	4	14	1	14	1

THE USER RANKING IS BASED ON LTC BOWSER'S RANKINGS.

THE ENGINEER RANKING IS AN AVERAGE OF THE RANKING OF CPT WOFFINDEN, MAJ ZAPKA AND CPT HALL.

THE GROUP RANKING IS AN AVERAGE OF ALL FOUR INDIVIDUAL RANKINGS FROM TABLE I.

### Overview of Current Computer Based Systems

In the research for this thesis, several computer based systems currently in use within the Armed Forces were examined. While most of the systems were for leadership training of some sort, others were being used for real world applications. The systems evaluated were:

- \* The Engineer Training System (ETS)- Used at the Engineer School Officer's Advanced and Basic Courses for training.
- \* MICROFIX (not an acronym) - A Military Intelligence information management and planning system.
- \* ZOG (not an acronym) - A Navy ship management system.
- \* The Army Tactical Frequency Engineering System (ATFES) - A Signal Corps information management and planning system.
- \* The Battalion Battle-Game Simulation System (BABAS) - A simulation based battalion staff training system.
- \* The Army Training Battle Simulation System (ARTBASS) - A simulation based battalion staff training system.
- \* JANUS (not an acronym) - A simulation based battalion staff training system.

The Engineer Training System (ETS). ETS is being used at the Engineer Officers Advanced and Basic Courses. Training on the system is in two areas. First, computer familiarization is taught. Specifically, officers are shown how to use applications programs such as Wordstar or Dbase II. The second area of training uses the computer for Engineer specific applications programs. Two of these programs are simulation based and allow the traversing of an NBC obstacle course and the planning of obstacles to stop an enemy attack respectively.

The system is based on a Cyber 810 minicomputer which is to be updated to a Cyber 830 in June of 1985. Connected to

the Cyber are 60 user terminals. All training takes place with the students sitting at the terminals. This system was selected for evaluation because it was the only system being used by any Officer Advanced Course for extensive computer related training (10;11).

MICROFIX. Microfix is a microcomputer system designed at the Georgia Institute of Technology (GIT) and is being used by the Military Intelligence (MI) Branch. It has been fielded at a level of one per MI battalion and is being primarily used as an information database. Information about units, troop movements, equipment and map locations may be entered into the system database. This information can also be overlaid on map backgrounds when needed. The computer uses the Apple II+ computer with a Z80B microprocessor added to it. The Z80B is the main processor for the system which uses the CPM operating system. The entire system is menu driven for ease of operator use (12;13). MICROFIX was selected for evaluation for three reasons:

1. User friendliness.
2. Use of videodisk technology for map storage.
3. Interfaces between the informational database and the videodisk.

ZOG. ZOG is a microcomputer based system developed by Carnegie Mellon University (CMU) for the United States Navy (USN). It is an operating system which makes extensive use of database manipulation, and as a result, is extremely user friendly. It is currently being tested on the USS Carl Vinson and is being used in three areas :

1. Command and control.
2. Maintenance.
3. An expert system for the control of flight operations.

ZOG uses a networked system of PERQ microcomputers. The PERQ is a 16 bit machine developed by people originally from CMU (14,15). ZOG was chosen for further evaluation for three reasons:

1. Command and control capabilities.
2. The use of videodisk technology for purposes other than map storage.
3. User friendliness of the ZOG operating system.

The Army Tactical Frequency Engineering System (ATFES).

ATFES is a system being used by the Army Signal Corps as an information management and planning system. The software in the system provides for:

1. Line of sight profiles between two locations.
2. Circuit routing and planning.
3. Line of sight area coverage from one point.
4. The maintaining of systems and equipment status records.
5. A digitalized terrain database.
6. Operations order preparation.

ATFES is currently implemented on PDP 11-70 minicomputers but is currently being upgraded to NCR Tower microcomputers. The Tower is a 16 bit machine based on the MC68000 microprocessor. The Tower is already being used in a testbed phase and is being deployed in Europe in the summer of 1985 (16). The ATFES/Tower system was chosen for further evaluation because of:

1. The extensive communications database information available.
2. The system is already being used by the Signal Corps.
3. The user friendliness of the system.

Battalion Battle-game Simulation System (BABAS). BABAS is a microcomputer based simulation system. It is used for the training of Combat Arms battalion staffs in battlefield management. Key to the implementation of BABAS is the fact that the personnel being trained never see a computer. Instead, they occupy an operations center just as they would in a normal combat situation. The simulation is run by controllers who are in a separate location and communicate with the battalion staff only by their organic communications means (wire or FM radio). Because of this separation, the battalion staff is made to feel that they are actually in the field engaged in a combat situation. They receive only the reports they would receive in actual combat and must make their decisions based on those reports. They then give their instructions back to the controllers who input them to the computer which continues the simulation based on these new actions (7).

BABAS is the current version of MACE. It uses a series of networked Corvus Concept microcomputers for the simulations. The Corvus Concept is a 16 bit machine which is based upon the MC68000 microprocessor (6).

BABAS was chosen for evaluation because of:

1. The realism involved for the people being trained.
2. The integration of videodisk technology and digitalized terrain information.
3. BABAS is the first microcomputer based battlefield management simulation system.

Army Training Battle Simulation System (ARTBASS). ARTBASS is a minicomputer based simulation system used to

train battalion staffs in battlefield management. With ARTBASS, like BABAS, the personnel being trained never see the computers. They establish an operations center in one location while the controllers are in a separate location with the computer resources. Additionally, the ARTBASS system is loaded on two 5 ton vans and is totally mobile so that it may go to where the user is. This allows the personnel being trained to establish their operations center in a location that is convenient to them.

ARTBASS uses two Perkins-Elmer 3240 minicomputers along with a Perkins-Elmer 3210 minicomputer. All use 32 bit technology (3).

ARTBASS was chosen for further evaluation for the following reasons:

1. It is the state of the art tactical simulator currently available.
2. The Army is fielding this system in November 1985.
3. ARTBASS has a 3-D terrain graphics capability.

JANUS. JANUS is a minicomputer based tactical simulation system that the Army Training and Doctrine Command (TRADOC) is considering for use as the standard training system for all Army branch schools. While the system has similar algorithms to those used by BABAS and ARTBASS, in JANUS, users sit at the terminals and interact directly with the computer. The user makes his decisions based on the information presented to him at the terminal and then inputs his instructions to the computer via keyboard (19).

JANUS uses a VAX 11/780 minicomputer which is a 32 bit machine. The system is configured so that there are 4

terminals connected to the VAX. JANUS is currently in a developmental phase and there are no plans for fielding it in the near future (19,20). JANUS was selected for further evaluation for the following reasons:

1. TRADOC is considering the system for standardization in all branch schools.
2. There is a complete battle simulation capability.

### III. SYSTEMS ANALYSIS

#### Introduction

In this chapter, each of the systems being considered was evaluated against the criteria established in Chapter II. A short narrative was given on how the system rates against each of the criteria and then a numerical score from 1 (Low) to 10 (high) was given. This score was given based upon the author's subjective comparison of the evaluated systems. At the end of the chapter a series of tables give the scores and rankings of the various systems, using the weighting schemes discussed in Chapter II.

#### The Engineer Training System (ETS)

Speed. The ETS has a clock cycle speed of 10 MHZ. Additionally, the bus speed is 5 MHZ per cycle. Speed from the mainframe to the terminals is approximately 56k bits per second (21:3).

Score: 8.

Expandability. The number of terminals available to the system is being expanded from 60 to 300. The Cyber 810 and 830 cannot be expanded by themselves although they may be replaced by larger machines at an additional cost. There are no current plans for expansion past the Cyber 830 with 300 terminals (21:2).

Score: 10.

Networking Capability. Currently there are 60 terminals networked with the Cyber 810. When the system is upgraded to

the Cyber 830, there will be 300 terminals worldwide with a dial in capability for those not located at Ft Belvoir. Calls will be multiplexed into the system over available lines. There are no current plans to network the Cyber itself with any other Cyber (11:1).

Score: 10.

Digital Terrain Capability. The ETS has no digital terrain capability (11:1).

Score: 0.

Graphics Capability. Currently, graphics are available only through PLATO and they may only be overlaid on other PLATO programs (11:2).

Score: 5.

Input/Output Capabilities. Users interact directly with the computer. Information may be input via keyboard, touch screen or mouse. Output capabilities include monochrome monitors and high speed dot matrix printers. Future plans include color monitors for a selected number of system terminals (11:1;10:1).

Score: 8.

Internal Memory. Internally the Cyber 810 and 830 are expandable to 32 megabytes (MB) of core memory (21:3).

Score: 10.

Map Storage. The ETS has no map storage capability (10:1).

Score: 0.

On Line Memory. The ETS may have up to 2.4 Gigabytes of on line memory. This includes hard disk and tape storage. Additionally, approximately one half of the terminals are equipped with eight inch floppy disk drives (10:1;21:3).

Score: 10.

Signal Database Software. The ETS has no Signal database software (10:1).

Score: 0.

Off Line Memory. For off line storage, the ETS uses magnetic tape (21:3).

Score: 8.

Commercial Software Availability. Programming is currently possible in Basic, Fortran, Cobol, and PLATO. It should be noted that PLATO allows non-programmers to program using a menu driven/information frame format. Commercial software being used includes Wordstar, Dbase II, Multiplan and Electronic Mail (11:1).

Score: 8.

Other Simulation Software Capability. Current simulation capabilities are limited to the Obstacle Planning program and the NBC Obstacle Course program which were noted in Chapter II. When The Obstacle Planning program is used, the system tends to degrade in response time if more than two users are running the program at the same time. There are no immediate plans for the development of other simulation programs (10:2).

Score: 2.

Security Capability. No secure data is being stored in the system. Users have a password to gain access to their files and they are limited by their student status to what files they may look at. Instructors have more access, and the systems controllers may access any files.

For modem link up, a callback system is to be implemented to prevent unauthorized off post access (10:2).  
Score: 3.

Other. One important additional factor about the ETS is that of the software development taking place, 43% is being written in house by Army officers at Ft Belvoir.  
Score: N/A.

#### MICROFIX

Speed. The speed of the Z80B microprocessor is 6 MHZ (12:1).  
Score: 4.

Expandability. All board slots within the Apple II+ are currently filled so there is no capability for further expansion as the system is currently designed (13:6;12:1).  
Score: 0.

Networking. Currently MICROFIX is a stand alone system and no networking takes place. Some consideration is being given to networking in the future, but no plans have been developed (12:1).  
Score: 0.

Digital Terrain Capability. MICROFIX has no digital terrain database (12:2).

Score: 0.

Graphics Capability. MICROFIX uses a joystick to control both the design and use of graphics for map overlays. The user can design his own graphics symbols and then recall them later for overlay purposes. Four colors are available for graphics usage. Graphics are available via screen output only; no print capability is available (12:2).

Score: 6.

Input/Output Capability. In addition to a keyboard, MICROFIX has a paper tape reader for input to the system. All map and graphics manipulations on the monitor are controlled by a joystick. For output, there is a dot matrix printer, a monochrome monitor for textual information and a color monitor for map display and graphics overlay. There is no graphics print capability (13:5;12:1).

Score: 8.

Internal Memory. Internally, MICROFIX has 128 kilobytes (k) of memory (13:6). This is not expandable.

Score: 3.

Map Storage. For map storage, MICROFIX uses a video disk which interfaces directly with the computer. Each video disk holds a different map area.

Actual photos of maps are stored on video disk. There is a capability to zoom to six different scales with the maps on the video monitor. Persatronics Corporation designed the video disks for the map capability. In doing so, they filmed

different scale maps for the different zoom levels rather than just moving the camera closer or farther away. This insured that the appearance of the maps was always detailed, unlike some of the other systems being rated. All map manipulations were controlled by a joystick and a menu on the monochrome screen, which in turn controlled what was taking place on the color monitor. This made the map interfacing capability extremely user friendly (13:9;12:1).

Score: 10.

On Line Memory. For on line storage, MICROFIX uses a 20MB hard disk. this stores all system programs and databases. Each system also has two floppy disk drives, which may store up to 390k (13:6-7).

Score: 3.

Signal Database Software. MICROFIX has existing signal software for the computation of High Frequency (HF) radio propagation predictions (13:11). No other signal database software is available.

Score: 2.

Off Line Memory. For off line storage, the system uses a video cassette recorder (VCR). One tape stores the software for the entire system. Additionally, there are two 5 1/4 inch floppy disk drives available for off line storage (13:7;12:1).

Score: 9.

Commercial Software Availability. The database information was coded using Dbase II. Other systems software

(map interface, graphics overlays) were coded using Apple Pascal. Other Commercial software with the system included Wordstar, Multiplan and Apple Basic (13:7).

Score: 7.

Other Simulation Software Capability. There is currently no simulation capability with MICROFIX and there are no plans to expand in this direction in the future (12:2).

Score: 0.

Security Capability. A tempest guarded version of the system is available. Additionally, there is a sanitization capability for all internal and on line memory. Users must have a password to access the system and individual files may also be password protected (13:12;12:1-2) .

Score: 5.

Other. In the design of this system, GIT used a philosophy they call " USE --> LEARN --> DEVELOP ". This process allowed them to field an initial system, and then modify the system depending on user complaints or suggestions. This allowed a quick initial fielding of the system and then improvements and extra features were added (12:1-2).

Score: N/A.

#### ZOG

Speed. ZOG has a 6 MHZ processor cycle time. The cycle time for the bus structure is 680 nanoseconds (ns) (15:90).

Score: 6.

Expandability. The ZOG network structure is expandable to let up to 42 users be networked together. The Perq computer is not internally expandable to allow for any future development. This is because the Perq was a specially designed machine which was not projected for any growth possibilities (15:96;14:2).

Score: 7.

Networking Capability. ZOG uses Ethernet to establish a Local Area Network (LAN). Currently they may network up to 42 separate terminals. The system is capable of multiprocessing between the terminals (15:96).

Score: 8.

Digital Terrain Capability. ZOG does not have any digitalized terrain database (14:2).

Score: 0.

Graphics Capability. ZOG has an excellent graphics capability which is menu driven. The Perq uses a window manager which allows the operator to manipulate screen information. There is a capability for picture development along with the use of graphs and charts of information (15:85).

Score: 8.

Input/Output Capability. For input, the Perq has both a keyboard and a mouse capability. For output, in addition to color monitors, the perq also uses two laser printers. In

addition to high quality print, the laser printers give graphics printouts with a resolution of 240 dots per inch (15:92).

Score: 7.

Internal Memory. The Perq computer has an internal memory capability expandable to 1 MB (15:90).

Score: 5.

Map Storage. ZOG does not have any current map storage capability; however, ZOG is already using videodisc technology for the storage of other types of static information. It would only be a matter of designing the map videodisc to give the system a map capability (15:93;22:1).

Score: 6.

On Line Memory. Each Perq has a built in 24 MB hard disk for on line storage (15:90).

Score: 4.

Signal Database Software. ZOG does not have any Signal database software.

Score: 0.

Off Line Memory. ZOG uses streamer tape for system backup and storage (15:90).

Score: 8.

Commercial Software Availability. the only commercial software included with ZOG is GRAFIKS, a graphics package. This lack of commercial software is due to the amount of software which was written into the ZOG operating system (15:85;14:2).

Score: 2.

Other Simulation Capability. ZOG does not have any simulation capability.

Score: 0.

Security Capability. All files on ZOG are password protected and you need a password to gain access to the system (14:2).

Score: 2.

Other. The future of the ZOG project is not clear at this point in time. Currently it is still in a developmental mode, but no organization in the Navy has picked the project up for future funding. CMU is no longer involved with ZOG. Instead, maintenance, troubleshooting and operations are being controlled by the Navy (14:2).

Score: N/A.

#### ATFES

Speed. The Tower microcomputer has a processor clock speed of 10 MHZ. Additionally, the bus cycle time is 200 ns (23:218-219).

Score: 8.

Expandability. The Tower computer has been designed so that it is expandable for future development. While the MC68000 microprocessor is a 16 bit machine, all of its internal registers and data bus lines are constructed to handle 32 bit transmissions, thus allowing possible conversion to a 32 bit processor (24:98). The tower itself controls all peripherals through separate removable control cards. Again this allows the ability to change or expand in

the future(25:6). For terminal expansion, each Tower may have up to 8 terminals connected to it (25:42).

Score: 8.

Networking Capability. In addition to 8 terminals connecting to each Tower, up to 4 Towers may be networked together. When networked, the systems have a full multiprocessing capability. In the future, the tower will be networked with the Ethernet LAN (25:40,25). ATFES itself is not currently being used in a networked mode.

Score: 5.

Digital terrain Capability. ATFES has a digital terrain capability which has a resolution to within 100 meters (26:1).

Score: 9.

Graphics Capability. Currently, the only graphics capability ATFES has is the printing of line of sight (LOS) information. The Tower has graphics software available, but it would need to be purchased separately (26:1;27:1).

Score: 5.

Input/Output Capability. for input, ATFES only has a keyboard capability. For output it uses monochrome monitors, a dot matrix printer for text and a laser printer for LOS graphics output (26:1). The Tower is also capable of output on a color monitor (27:1).

Score: 7.

Internal Memory. The Tower has an internal memory expandable up to 8 MB (27:1). ATFES comes equipped with 2 MB of internal memory (28:8).

Score: 7.

Map Storage. ATFES currently has no map storage capability; however, the Tower is capable of interfacing with a videodisc player, so the technology is available once a map videodisc is developed (27:1;22:1).

Score: 4.

On Line Memory. The Tower is capable of supporting up to 1 gigabyte of on line storage. This is completed through a series of 8 inch Winchester hard discs (29:5-6). ATFES comes with 46 MB of hard disc storage (28:8).

Score: 8.

Signal Database Software. ATFES has the following Signal database software:

1. Line of Sight calculations.
2. Terrain profile calculations.
3. Multichannel frequency assignment calculations.
4. Circuit routing and systems status records.
5. Operations order form generator.
6. Equipment status logs.
7. Critical events log.
8. Personnel status logs.
9. Historical storage capability for LOS information.
10. Capable of drawing circuit routing charts and multichannel systems diagrams (29:1-9;16:21-22).

Score: 10.

Off Line Memory. For off line storage, ATFES uses streamer tape (25:49).

Score: 8.

Commercial Software Availability. ATFES comes with wordprocessing, Fortran and database management. Because of

the specialized programs developed for ATFES, other commercial software is not included (26:1).

Score: 5.

Other Simulation Capability. ATFES does not have any simulation capability.

Score: 0.

Security Capability. To enter ATFES you must have a password. Additionally, files may be password protected (26:1).

Score: 2.

#### BABAS

Speed. With the MC68000 microprocessor, BABAS has a cycle speed of 10 MHZ. While running simulations, BABAS gives an update every four minutes (23:218-219;6:1).

Score: 7.

Expandability. Like ATFES, BABAS allows for future expansion with 32 bit technology through use of the MC68000 microprocessor (24:98). The number of BABAS users is limited to one set because of BABAS's unique separation of trainees and computer controllers. There are no provisions for expanding the number of staffs that may be controlled by one network of computers (6:2).

Score: 7.

Networking Capability. BABAS uses seven Corvus Concept microcomputers which are networked together via OMNINET, a LAN developed by Corvus. The network is used to link all

stations to a central memory location, but no multiprocessing takes place between stations (17:5).

Score: 6.

Digital Terrain Capability. BABAS has a digital terrain database which has a resolution to 100 meters (17:9;6:2).

Score: 9.

Graphics Capability. With BABAS you are allowed to design your own graphics to be used for map overlays. Four colors are available for this purpose. There is not a graphics print capability. The graphics are all menu driven, and are controlled through the use of a joystick. this makes the entire operation of the graphics interface very user friendly (6:2).

Score: 7.

Input/Output Capability. BABAS uses three forms of input. There is a keyboard and mouse for text input and manipulations and a joystick is used for all interfaces with the map capability. It should also be noted that the keyboard has several special function keys which make operator interface with the system extremely user friendly. For output, BABAS uses dot matrix printers, monochrome monitors for text, and color monitors for map and graphics interface (17:6; 6:2).

Score: 8.

Internal Memory. The Corvus Concept computers have 512k of internal memory (6:2).

Score: 4.

Map Storage. BABAS utilizes videodisc technology to give a map capability. While there are 6 different levels of zoom, all levels are not clear. Unlike MICROFIX, which used different sizes of maps for the different zoom levels, BABAS used only one size of map (1:50,000) and created the zoom levels by moving the camera closer or further away from the map. This causes blurriness at the largest two zoom levels (6:2).

Score:8.

On Line Memory. For on line storage, BABAS uses two 20MB hard discs. One stores the digitalized terrain database, while the second stores all system databases and simulation algorithms (17:5;6:1).

Score: 5.

Signal Database Software. BABAS has the capability of computing line of sight between two points or line of sight for an area of coverage. Once calculated, the line of sight profile is overlayed on the map video (6:3). No other communications software is available.

Score: 2.

Off Line Memory. For off line storage, BABAS uses video tape and a Panasonic video recorder (6:3).

Score:9.

Commercial Software Availability. BABAS only comes with Pascal (6:3). All other software was coded directly for BABAS.

Score:2.

Other Simulation Capability. BABAS can simulate up to 250 units at one time. Specific activities which can be simulated include:

1. Troop Movements.
2. Troop Engagements.
3. Indirect fire.
4. Nuclear and chemical attacks.
5. Logistics play.
6. Administrative play.
7. Engineer obstacle play.

The average time for a situation update is four minutes (17:7-9).

Score: 7.

Security Capability. Users must have a password to log on to the system (6:3).

Score: 2.

Other. BABAS is entirely menu driven which causes it to be extremely user friendly. Currently, BABAS is still in a testing mode so there is no support program except at Fort Leavenworth, Kansas. At this time there is no projected fielding date. The current cost is \$73,000 per system (6).

#### ARTBASS

Speed. With the Perkins Elmer minicomputer, ARTBASS has a processor cycle speed of 10 MHZ. Additionally, while the simulations are running, ARTBASS is capable of giving a situation update every one minute as opposed to BABAS which gives an update every four minutes (5:2). This is accomplished by multiprocessing which takes place between the three Perkins Elmer computers.

Score: 8.

Expandability. There have been no provisions made for ARTBASS to expand in the future without a complete removal of existing equipment. Because ARTBASS is kept in a mobile five ton van, space constraints also create a limit on the amount of expansion that may occur. The only expansion that is possible would be through further networking of the Perkins Elmer computers, but no current consideration has been given to this (5:2).

Score: 2.

Networking Capability. Currently, there are two Perkins Elmer model 3240 computers networked with a Perkins Elmer model 3210 computer. All three computers are capable of multiprocessing and use a shared memory (3:6).

Score: 7.

Digital Terrain Capability. ARTBASS has the best digitalized terrain capability of all systems viewed. The major advantage of the system is that it has a resolution to 25 meters while all other systems only use 100 meter resolution (3:1).

Score: 9.

Graphics Capability. ARTBASS has a conventional graphics capability similar to BABAS or MICROFIX which allows military symbols to be overlayed onto a map which is also created by graphics (as opposed to being a photographed map stored on a video disc). Additionally, ARTBASS has a 3-D view graphics capability which allows the user to obtain a 3-D view from any point on the map. All elevation and relief features are

then shown in 3-D and the user has the feel of actually viewing the terrain (18:14; 5:1).

Score: 9.

Input/Output Capability. For input, ARTBASS uses a keyboard, a bit pad, and has a touch sensitive screen capability. The keyboard has 16 special function keys which allow for easier user operation. Additionally, all operations are menu driven which allows for use of the touch sensitive screen or the special function keys (18:6). For output, ARTBASS uses dot matrix printers, monochrome monitors for text and a color monitor for map and graphics output (18:4).

Score: 9.

Internal Memory. For internal memory, each of the Perkins Elmer 3240s has 2 MB. The 3210 has .75 MB of internal memory (3:6).

Score: 6.

Map Storage. ARTBASS does not store maps on video disc as MICROFIX and BABAS do. Instead, the maps are projected using a graphics format. Although there are six different levels of zoom, the graphics do not present images as clearly as the photographed maps stored on video disc. this precludes the detailed map viewing that is required for signal analysis. The advantage of the ARTBASS format is that it allows the user to obtain a 3-D view if he so desires (5:1).

Score: 4.

On Line Memory. For on line memory, each of the Perkins Elmer 3240 computers has a capability of 300 MB of hard disc

storage. The 3210 can store up to 10 MB of information (5:3).  
Score: 7.

Signal Database Software. The only signal database software capability that ARTBASS has is a line of sight capability. This is used for observation purposes on the graphics screen so that the user may only see those units with which he has line of sight contact (5:2).  
Score: 2.

Off Line Memory. For off line storage, ARTBASS uses streamer tape (5:3).  
Score: 8.

Commercial Software Availability. The only software packaged with ARTBASS is a Fortran compiler, which is used for in house software development (5:3).  
Score: 2.

Other Simulation Capability. ARTBASS had the most sophisticated tactical scenario simulator of all the systems viewed. Capabilities included:

1. Reconnaissance.
2. Hasty/Deliberate attack.
3. Defensive operations.
4. Retrograde operations.
5. Air operations.
6. Indirect fire.
7. Weather.
8. NBC play.
9. Air defense.
10. Administrative and logistics play.

Additionally, there is a situation update every one minute (18:14-18; 5:1).  
Score: 9.

Security capability. In the future, designers are considering a tempest protected version of ARTBASS, however, there are no current security capabilities (5:1).

Score: 0.

Other. ARTBASS will be fielded in the fall of 1985 at several unit locations throughout the Army. In the 1987/88 time frame it will be installed at the Infantry and Armor Officers Advanced Courses (5:1). The current cost of the system is \$3 million dollars per system.

Score: N/A.

#### JANUS

Speed. Since JANUS uses a VAX 11/780 minicomputer, the processor speed is 10 MHZ. However, the VAX also has a cache memory capability which reduces the average memory access time from 600 ns to 270 ns. This access reduction time makes the VAX faster than any of the other systems viewed (30:9).

Score: 9.

Expandability. JANUS is currently configured to handle 4 users at a time although the VAX is capable of having many more users. The VAX itself cannot be expanded (19:1;30:14).

Score: 5.

Networking Capability. Currently JANUS has four terminals connected with the VAX, however many more users may be on the VAX. The number of users is limited only by the number of I/O controller cards which are interfaced with the VAX bus structure. Due to the amount of processor time used in running the simulations, it was impractical to have more

than four users. After that, the processor would begin to bog down (19:1). More than one VAX may be networked together, but there would be a significant increase in cost.

Score: 7.

Digital Terrain Capability. JANUS has a digital terrain capability with a resolution of 100 meters (19:2).

Score: 8.

Graphics Capability. JANUS has a graphics capability which is similar to that of ARTBASS. The map board is a graphics representation on an actual map and is in full color. Map symbols and units may be overlayed onto the graphical map. The graphics view may also be 3-D as with ARTBASS although the resolution is not as good (19:1;20:2-3).

Score: 7.

Input/Output Capability. For input, JANUS uses only a normal keyboard. For output, the system has monochrome monitors for text, color monitors for map/graphics presentations and printers with a capability of 1200 lines per minute for paper output (19:2; 20:8).

Score: 6.

Internal Memory. JANUS has 2 MB of internal memory, but the VAX is expandable to 8 MB of internal memory (20:8; 30:8).

Score: 7.

Map Storage. Like ARTBASS, JANUS has no capability for the storage of photographed maps on video disc. Instead, it has graphical representations of all maps which may be viewed

from a 2-D or 3-D view. The resolution is not as clear as with the photographed maps on video disc (20:2; 19:1).

Score: 4.

On line Memory. JANUS uses a 516 MB hard disc for on line storage, but the VAX is expandable to 4.3 gigabytes of on line memory (20:8; 30:9).

Score:10.

Signal Database Software. The only signal database software capability that JANUS has is a line of sight capability which takes into account terrain, trees, building and clouds. This is used for line of sight acquisition, observation and target engagement (20:2).

Score: 2.

Off Line Memory. For off line storage, JANUS uses streamer tape (20:8).

Score: 8.

Commercial Software Availability. Software that comes with JANUS includes a Fortran compiler and GRAFAK, a graphics package. All other software is designed in house (19:2).

Score: 4.

Other Simulation Capability. JANUS has simulation capabilities similar to ARTBASS, however, there is neither an air capability, nor an indirect fire capability (19:1).

Capabilities include:

1. Reconnaissance.
2. Hasty/Deliberate attack.
3. Defensive and retrograde operations.
4. Weather.
5. NBC play.
6. Administrative and logistics play.

Since the user sits at the computer screen and inputs his own decisions, there is not as much realism as with ARTBASS or BABAS (19:1).

Score: 5.

Security Capability. JANUS has no security measures built in at this time (19:1).

Score: 0.

Other. Currently there are no plans for deployment of JANUS. The system is still in a developmental mode and there are numerous problems with the software. The system is being considered for use by combat developers, who look at an isolated section of the battlefield instead of the total battle. The current cost of JANUS is \$386,331 per system (19:1).

Score: N/A.

#### System Selection

A summation of the scores for all systems, along with their unweighted totals, is given in Table III. The system which has the highest unweighted score is the ATFES system with a score of 86. In Table IV, the point totals are given using the user (LTC Bowser) criteria rankings and weightings. Table V gives the point totals using the Engineer criteria rankings and weightings, while Table VI gives the point totals using the total group rankings (For a definition of the engineer ranking and the group ranking, see chapter II). For all tables, the criteria weighted scores were obtained by multiplying the scores given in Table III, by the weightings

given in column two of each table. In all cases, the highest rated system was ATFES, using The Tower microcomputer. Based upon these ratings, ATFES was chosen for further study as the system that the SCIT system design would be based upon. This design is completed in Chapter 4.

TABLE III  
SYSTEM SCORE TOTALS WITH NO WEIGHTING

<u>CRITERIA</u>	<u>ENG SYSTEM</u>	<u>MICRO- FIX</u>	<u>ZOG</u>	<u>ATFES</u>	<u>BABAS</u>	<u>ARTBASS</u>	<u>JANUS</u>
SPEED:	8	4	6	8	7	8	9
EXPANDABILITY:	10	0	7	8	7	2	5
NETWORKING CAPABILITY:	10	0	8	5	6	7	7
DIGITAL TERRAIN CAPABILITY:	0	0	0	9	9	10	9
GRAPHICS CAPABILITY:	5	6	8	5	7	9	7
INPUT/OUTPUT CAPABILITIES:	8	8	7	7	8	9	6
INTERNAL MEMORY:	10	3	5	7	4	6	7
MAP STORAGE:	0	10	6	4	8	4	4
ON LINE MEMORY:	10	3	4	8	5	7	10
SIGNAL DATABASE SOFTWARE:	0	2	0	10	2	2	2
OFF LINE MEMORY:	8	9	8	8	9	8	8
COMMERCIAL SOFTWARE AVAILABILITY:	8	7	2	5	2	2	4
OTHER SIMULATION SOFTWARE CAPABILITY:	2	0	0	0	7	9	5
SECURITY CAPABILITY:	3	5	2	2	2	0	0
<b>**TOTAL**</b>	82	57	63	86	83	83	83

TABLE IV  
SYSTEM SCORE TOTALS WITH USER WEIGHTINGS ONLY

<u>CRITERIA</u>	<u>W E I G H T</u>	<u>ENG SYSTEM</u>	<u>MICRO- FIX</u>	<u>ZOG</u>	<u>ATFES</u>	<u>BABAS</u>	<u>ARTBASS</u>	<u>JANUS</u>
SPEED:	13	104	52	78	104	91	104	117
EXPANDABILITY:	8	80	00	56	64	56	16	40
NETWORKING CAPABILITY:	5	50	00	40	25	30	35	35
DIGITAL TERRAIN CAPABILITY:	9	00	00	00	81	81	90	81
GRAPHICS CAPABILITY:	7	35	42	56	35	49	63	49
INPUT/OUTPUT CAPABILITIES:	14	112	112	98	98	112	126	84
INTERNAL MEMORY:	12	120	36	60	84	48	72	84
MAP STORAGE:	10	00	100	60	40	80	40	40
ON LINE MEMORY:	11	110	33	44	88	55	77	110
SIGNAL DATABASE SOFTWARE:	2	00	04	00	20	04	04	04
OFF LINE MEMORY:	6	48	54	48	48	54	48	48
COMMERCIAL SOFTWARE AVAILABILITY:	3	24	21	06	15	06	06	12
OTHER SIMULATION SOFTWARE CAPABILITY:	1	02	00	00	00	07	09	05
SECURITY CAPABILITY:	4	12	20	08	08	08	00	00
<b>**TOTAL**</b>		697	474	554	710	681	690	709

TABLE V  
SYSTEM SCORE TOTALS WITH ENGINEER WEIGHTINGS

<u>CRITERIA</u>	<u>WEIGHT</u>	<u>ENG SYSTEM</u>	<u>MICRO-FIX</u>	<u>ZOG</u>	<u>ATFES</u>	<u>BABAS</u>	<u>ARTBASS</u>	<u>JANUS</u>
SPEED:	12	96	48	72	96	84	96	108
EXPANDABILITY:	13	130	00	91	104	91	26	65
NETWORKING CAPABILITY:	14	140	00	112	70	84	98	98
DIGITAL TERRAIN CAPABILITY:	10	00	00	00	90	90	100	90
GRAPHICS CAPABILITY:	11	55	66	88	55	77	99	77
INPUT/OUTPUT CAPABILITIES:	8	64	64	56	56	64	72	48
INTERNAL MEMORY:	7	70	21	35	49	28	42	49
MAP STORAGE:	6	00	60	36	24	48	24	24
ON LINE MEMORY:	5	50	15	20	40	25	35	50
SIGNAL DATABASE SOFTWARE:	9	00	18	00	90	18	18	18
OFF LINE MEMORY:	4	32	36	32	32	36	32	32
COMMERCIAL SOFTWARE AVAILABILITY:	3	24	21	06	15	06	06	12
OTHER SIMULATION SOFTWARE CAPABILITY:	2	04	00	00	00	14	18	10
SECURITY CAPABILITY:	1	03	05	02	02	02	00	00
<b>**TOTAL**</b>		<b>668</b>	<b>354</b>	<b>550</b>	<b>723</b>	<b>667</b>	<b>666</b>	<b>681</b>

TABLE VI  
SYSTEM SCORE TOTALS WITH GROUP WEIGHTINGS

<u>CRITERIA</u>	<u>W E I G H T</u>	<u>ENG SYSTEM</u>	<u>MICRO- FIX</u>	<u>ZOG</u>	<u>ATFES</u>	<u>BABAS</u>	<u>ARTBASS</u>	<u>JANUS</u>
SPEED:	14	112	56	84	112	98	112	126
EXPANDABILITY:	13	130	00	91	104	91	26	65
NETWORKING CAPABILITY:	12	120	00	96	60	72	84	84
DIGITAL TERRAIN CAPABILITY:	11	00	00	00	99	99	110	99
GRAPHICS CAPABILITY:	10	50	60	80	50	70	90	70
INPUT/OUTPUT CAPABILITIES:	9	72	72	63	63	72	81	54
INTERNAL MEMORY:	8	80	24	40	56	32	48	56
MAP STORAGE:	7	00	70	42	28	56	28	28
ON LINE MEMORY:	6	60	18	24	48	30	42	60
SIGNAL DATABASE SOFTWARE:	5	00	10	00	50	10	10	10
OFF LINE MEMORY:	4	32	36	32	32	36	32	32
COMMERCIAL SOFTWARE AVAILABILITY:	3	24	21	06	15	06	06	12
OTHER SIMULATION SOFTWARE CAPABILITY:	2	04	00	00	00	14	18	10
SECURITY CAPABILITY:	1	03	05	02	02	02	00	00
<b>**TOTAL**</b>		<u>687</u>	<u>372</u>	<u>560</u>	<u>719</u>	<u>688</u>	<u>687</u>	<u>706</u>

#### IV. SCIT System Design

##### Introduction

This chapter presents the design for the SCIT system based upon ATFES, with the Tower microcomputer. Although the specific equipment being used is from the Tower system, several ideas from other systems are being incorporated into this design. These ideas include the use of video disk technology for map presentations, as was used with MICROFIX and BABAS, and the separation of the student from the computer which is performing the actual simulation, as was done with BABAS and ARTBASS.

This chapter has three separate sections. The first section gives a detailed view of the current configuration of the Tower microcomputer in support of ATFES. The second section presents an overview of the proposed SCIT system concept and design. The final section gives a detailed hardware design of the proposed SCIT system.

##### The Current Tower/ATFES Hardware Configuration

As noted in chapter III, the Tower microcomputer is designed for ease of expansion and configuration. Figure 1 gives a block representation of the internal structure of the Tower without any peripherals attached. It should be noted that there are several separate controller cards. The 5.25 inch media card supports up to three 5.25 inch floppy disks and three 5.25 inch Winchester hard disks. The 8 inch media controller provides access for up to one gigabyte of memory

through use of 8 inch Winchester hard disks. The 8-Channel I/O controller supports up to eight RS-232-C interface devices, to include terminals and printers. The Ethernet controller provides the capability for the Tower to connect to a LAN, while the Streaming Tape Controller provides the interface for streamer tape off line storage. Also, there is one open slot which may be used to interface any special devices (25:6,44).

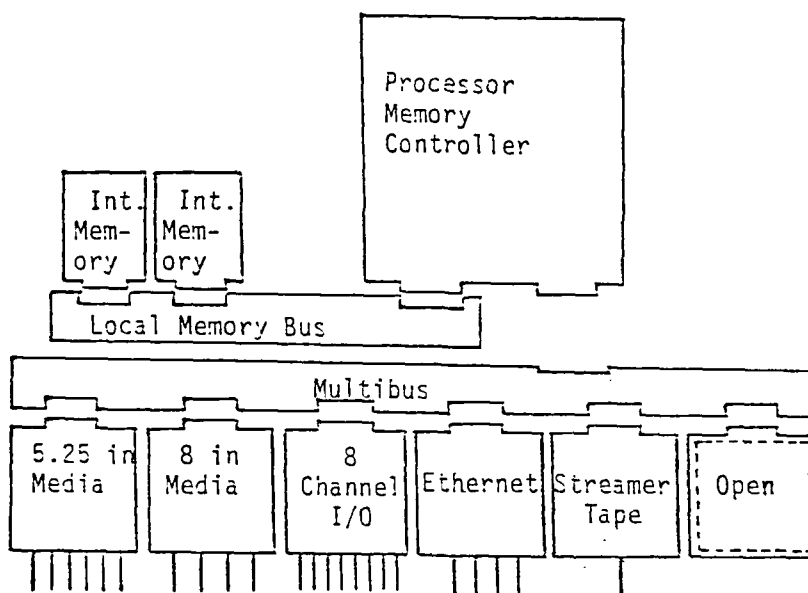


Figure 1. Tower Architecture (25:44)

Currently, ATFES has the 2 MB of internal memory indicated in Figure 1. Attached to the 5.25 inch media controller card are a 1 MB floppy disc drive and a 46 MB hard disk. Attached to the 8-Channel I/O controller are two monochrome monitors, a dot matrix printer, and a laser printer for line of sight graphics plots. Off line storage is provided by attaching one 45 MB streamer tape device to the Streamer Tape controller (28:8). Figure 2 reflects this present architecture. Note that the 8 inch media controller and the Ethernet controller are not used.

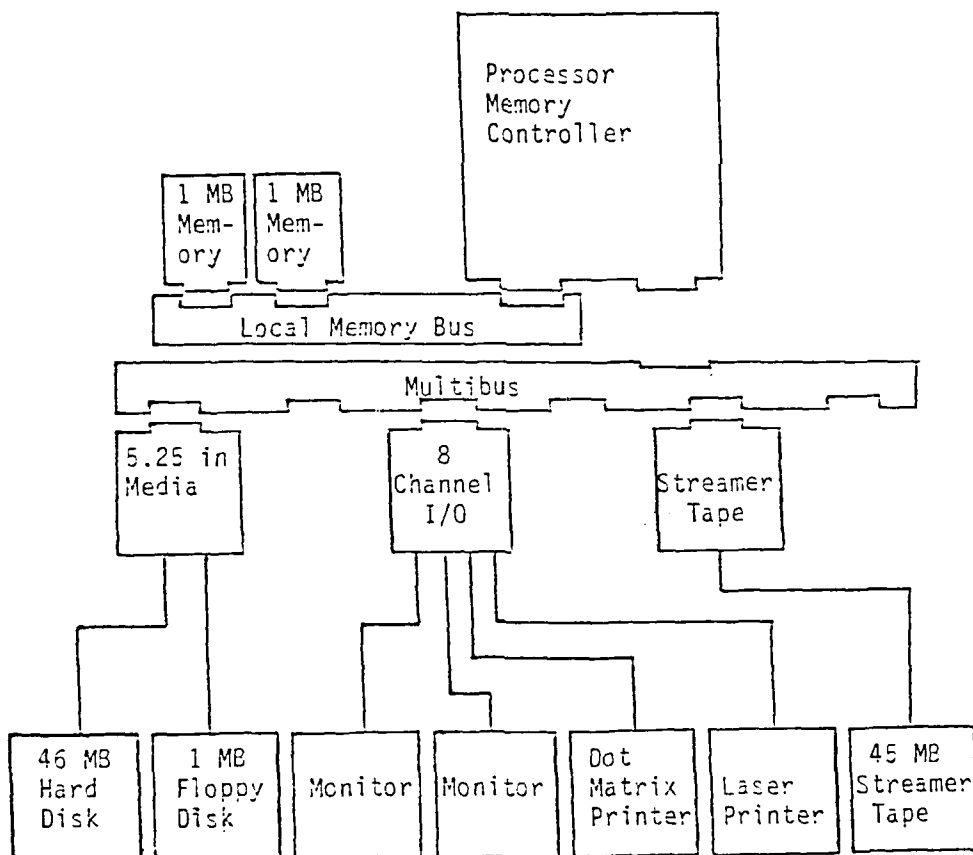


Figure 2. Current Tower/ATFES Architecture

### A Conceptual Overview of the Proposed SCIT System

Conceptually, the proposed SCIT system design is similar to that of BABAS or ARTBASS. That is, the students being trained will be separated from the computer controlling the simulation. Students as used in this chapter refers to those officers being trained in communications network management. The term controllers will refer to the permanent cadre that will be responsible for the training of the students in communications network management.

First, a mock Signal battalion systems control (Syscon) center would be established in a room or van. This center should appear just as an actual Syscon van would in the field. That is, there should be an FM radio, telephones, map boards, bulletin boards, and an ATFES system configured in its normal manner. The ATFES system will be referred to as the Syscon Computer in this chapter. This room would be used by the students being trained.

In a separate room, the exercise controllers would have their operations center. Here, they would have an FM radio, telephones, any bulletin/chalk boards needed, and a Tower microcomputer. This Tower microcomputer will be referred to as the Controller Computer in order to avoid confusion with the Tower Microcomputer in the Syscon room. The FM radio would be on the same frequency as the Syscon radio, and the telephone would be wired to the Syscon telephone. The Controller Computer would be networked with the Syscon Computer and would contain the simulation software.

The simulation software in the Controller Computer would be probability based, and would use random number generators to control the simulated installation of the communications network. Communications link installation times, communications link failures, equipment failures, channel installation times, and site relocations are just some of the events that could be controlled by the simulations. All would have probabilities of occurrence based upon data gathered from actual signal battalion communications network installations.

Figure 3 shows a block diagram of the entire SCIT system, to include both the Syscon center and the Controller center.

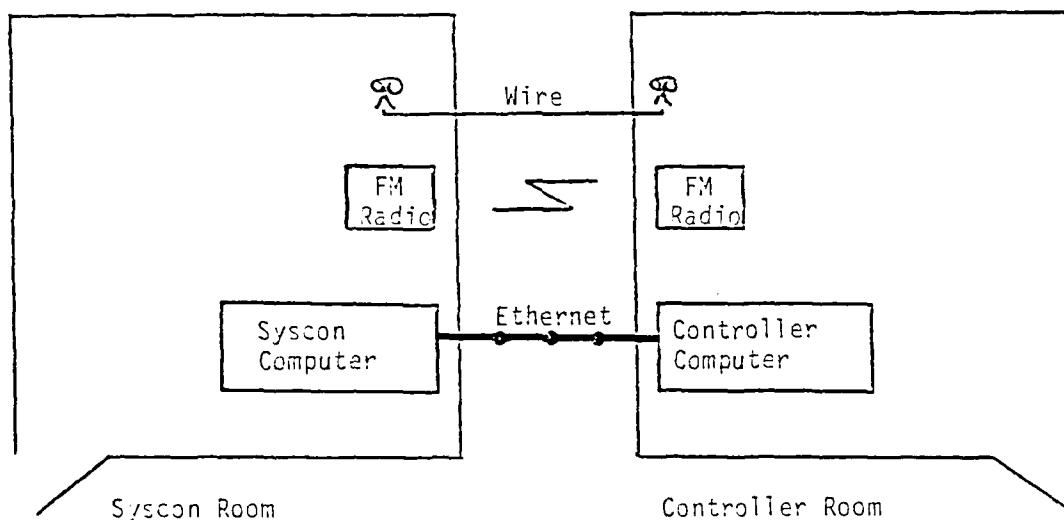


Figure 3. Proposed SCIT System Block Diagram

An exercise would proceed as follows. The students in the Syscon room would be given a mission and Oporder from the chief controller. Using the ATFES software on the Syscon Computer, they would plan their communications networks, and write the Oporder for their "subordinate units. In using ATFES, the students would input all communications network information into databases controlled by the Syscon Computer. This would include separate databases for site locations, line of sight elevation information, system link routing information, circuit routing information, and equipment status information. As will be seen shortly, it is important that the information is entered correctly, as it will be used by the subsequent simulations.

Once the students have entered all information through ATFES and written an Oporder, they brief the controllers at their Syscon room just as they would brief subordinate company commanders and platoon leaders. In fact, the controllers will be acting as platoon leaders/site commanders during the exercise and will be following the orders of the Syscon personnel.

After receiveing the briefing, the controllers depart the Syscon room and go to the Controller room. By departing the Syscon room, the controllers are simulating leaving the area with their platoons, and proceeding to their site locations to install the communications network. All subsequent communications between students and controllers are only via FM radio or telephone as appropriate.

Upon arrival at the Controller room, the chief controller would assign separate communications links and sites to each controller. In other words, each controller would be the platoon leader for particular sites, and would control the simulations for those links. At this time the Controller Computer would be activated and simulations would begin. Each "platoon leader" would radio Syscon to inform them of their unit's arrival on location and that communications system initialization was taking place.

Each controller would have a separate terminal connected to the Controller Computer. Using the simulation software in the Controller Computer, he would access the database information stored in the Syscon Computer for each of his communications links and sites. Once this information was obtained, the Controller Computer would begin its simulation for each communications link being installed. As each link's installation is being simulated, the appropriate controller would be informed via screen or printed output of the status of the installation. If there was a problem with a particular link or channel installation (with a problem being simulated by the computer), the computer would inform the controller and give particular symptoms. The controller, acting as platoon leader, would then contact the Syscon students via the FM to report the problem and symptoms, and to ask for aid in solving the problem. The Syscon students would decide what course of action should be completed and call back to the appropriate platoon leader/controller with instructions. The controller would then input the

instructions to the computer and the simulation would continue based upon the instructions given. If the advice solved the problem, the link would continue towards installation. If it did not solve the problem, there would be no change in the situation. In either case, the computer would inform the controller, who as platoon leader, would then inform Syscon.

As an example, it might be that a PCM radio link is not coming in, and the receivers at both ends have low receive signals. The Controller Computer would inform the controller, who would call Syscon with the problem (PCM radio link not in), and with the symptom (low receive signal). After being informed of the problem, the Syscon students might decide the line of sight profile is marginal, and that the antenna should be raised 15 feet. They would then inform the platoon leader of this via FM, and he would input the information to the Controller Computer. Assuming that was the correct advise, the computer would report the system in and the controller would then call Syscon so they could log the system in.

This example shows just one simulation, but there would of course be simulations going on for all communication links being installed. Once all systems were installed, the controllers could cause the tactical situation to change, so that the Syscon trainees would need to have units move to meet the new situation. The simulation could continue for as

long as the controllers felt it was necessary, and afterwards the trainees could be appraised of their performance.

There are three keys to the operation of this system. First, the information input to the ATFES databases by the students must be accurate. Otherwise, when the Controller Computer accesses the databases, the simulations will be based on erroneous information. Second, the Controller Computer must be networked with the Syscon ATFES computer so that it has complete access to the databases of information there. This information provides the initial scenario for the simulations and without it, nothing can proceed. Finally, and most importantly, the students use the ATFES computer only in the manner it would be used in the field. All simulations are initiated by the Controller Computer and there is no direct interface between that computer and the students.

If the SCIT System is operated as outlined here, the students would not only receive training on the use of ATFES, but the SCIT system would provide training on supervising a communications network where there are real world type problems. By having the controllers separate from the students, there is a greater degree of realism and there are no extra computer learning demands for the students. From the student point of view, they actually could be in a Syscon van at a field location controlling a communications network. The SCIT system would be able to put pressure on them which would be very similar to the pressure received during an actual field exercise, and would be much more realistic than any classroom training.

#### The Hardware Design of the Propose SCIT System

There are three separate areas to be considered in the design of the SCIT system: the Syscon Computer configuration, the network, and the Controller Computer configuration. The Syscon Tower would be configured similarly to the ATFES Tower configuration presented at the start of this chapter. Internally, there would be 2 MB of memory, just as with the original ATFES Tower. For on line memory, the Tower would have the same 46 MB hard disk and 1 MB floppy disk connected to the 5.25 inch Media controller card. For off line storage, the system would use the same 45 MB streamer tape and controller as in the original ATFES Tower. For user interfaces, there would be two monochrome monitors, a dot matrix printer, and a graphics printer all connected to the 8-channel I/O card. The change to the system, is that an Ethernet controller card would be added to the system. This allow the connection of the Tower to an Ethernet Transceiver, which would then allow the system to be connected in a LAN. this Tower configuration is shown in Figure 4.

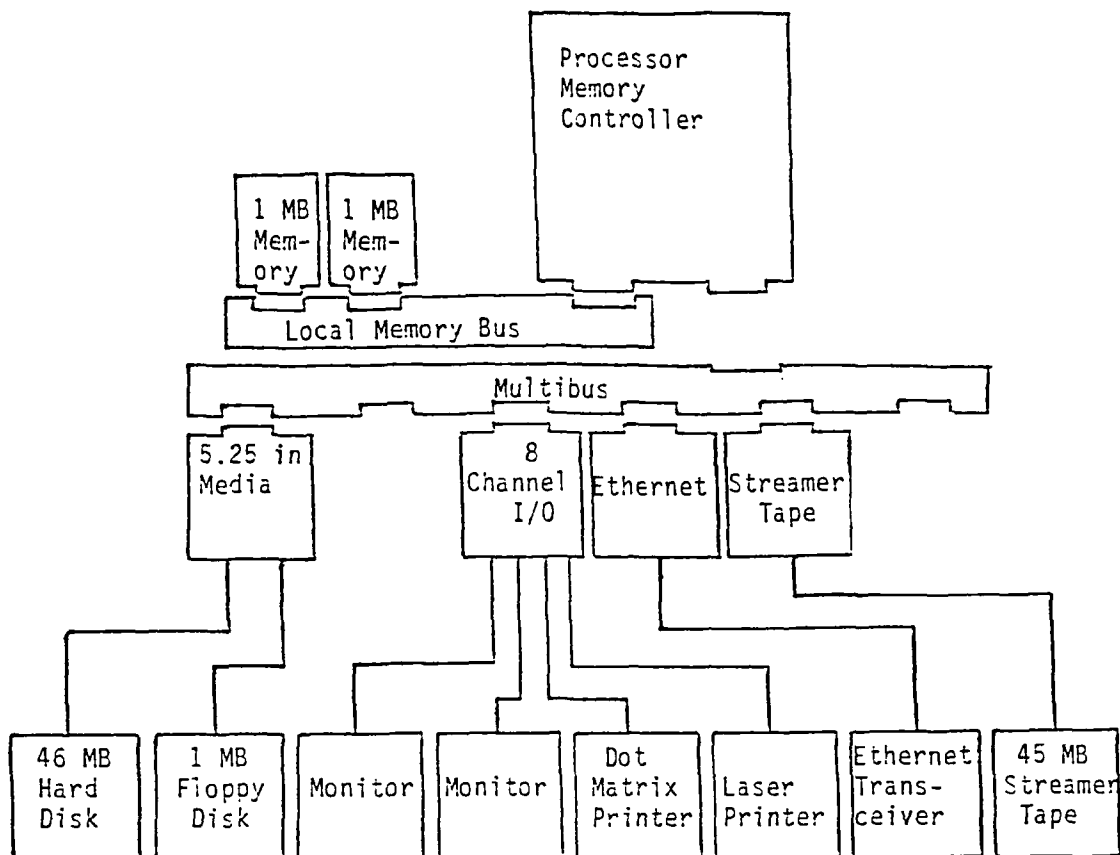


Figure 4. Proposed ATFES Tower Configuration.

The network itself would use the Xerox Ethernet. This LAN is the current network configuration available with the TOWER, and is in fact one of the standards for LAN implementations. For each separate Tower connected to the LAN there would be an Ethernet transceiver, which provides the actual interface to the Ethernet structure.

For the Controller Computer, the configuration would be somewhat different from the Syscon Computer. NCR has a newer machine, called the Tower XP, which uses a MC68010 chip as the main processor. Included with the XP are 2 K bytes of cache memory, which allow for less time to be spent on memory fetches by having a localized processor memory which would store those instructions or data used most often. This system should form the center of the controller Tower. For internal

memory, the Controller Computer should use the entire eight MB available. By utilizing all eight MB of memory, the system will have to spend less time on memory fetches from the hard disk, and speed should be improved. A diagram of this internal core structure, before any peripherals are added, is shown in Figure 5.

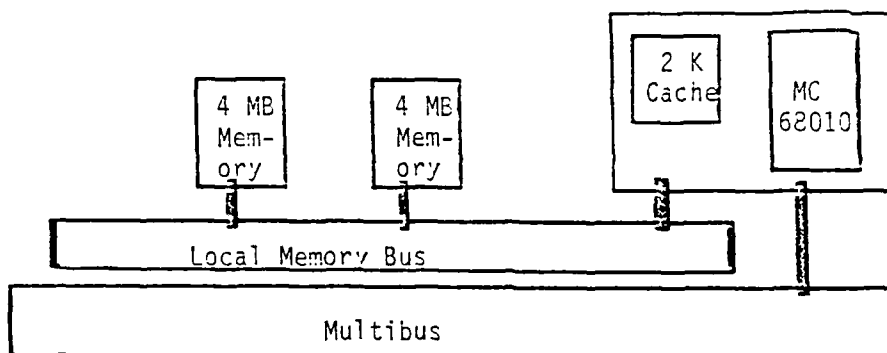


Figure 5. Proposed Controller Tower Internal Core Structure

Attached to the Multibus would be four controller cards: an 8 inch media controller card, an 8-Channel I/O controller card, a controller card to interface a laser video disk, and an Ethernet controller card. Attached to the Ethernet controller card would be the Ethernet transceiver which would allow access to the LAN. There would not be a 5.25 inch controller card or a streamer tape controller card. For streamer tape backup, and for floppy disk usage, the

controller system would use the LAN configuration to access the equipment on the Syscon Computer.

At this time, the amount of on line storage capability needed for the simulation software is not known and will not be known until the software is actually being written. If BABAS and ARTBASS are used as models, an estimate of the amount of memory needed can be made. BABAS uses a 20 MB hard disk for simulation storage, while ARTBASS uses a 300 MB hard disk; however, the ARTBASS hard disk also contains the digital terrain information, and the information needed to provide the 3-D graphics capability (6:1; 5:3). Based upon this, the system should start with one 84 MB hard disk connected to the 8 inch controller card. If this does not prove to be enough on line memory, additional hard disks may be added to increase the memory as needed.

For user interfaces, the number of controllers can again be determined by examining BABAS and ARTBASS. Both use four operators to control the different units being simulated. Three operators are responsible for specific units and the fourth is the overall controller. In order to do this, the SCIT system would need four monitors connected to the 8-Channel I/O controller card. A separate color monitor would be needed in order to provide map and graphic overlay capabilities. Additionally, two printers would be needed for text and graphics printed output. This would mean that a total of seven of the eight available I/O ports would be used. If in the future it was determined that more user interfaces were needed, a second I/O controller card could be

added to allow for a total of 16 I/O devices.

The video disk interface card would be used in the open slot on the Multibus. This would interface to the video disk equipment which would provide the map capability for the system. The video disk player would be the standard player used by NCR with their micro computer systems.

Figure 6 gives a block diagram of the Controller Computer.

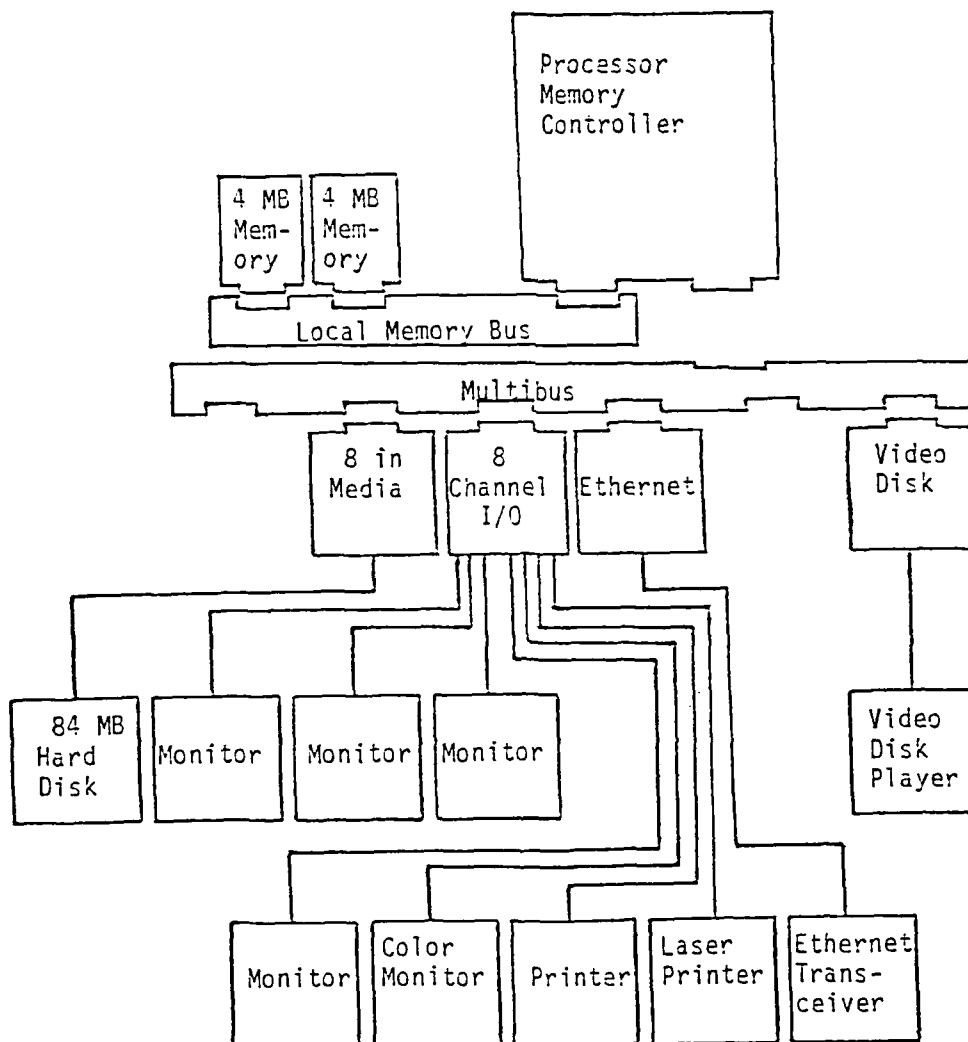


Figure 6. Proposed Controller Tower Configuration

If the ATFES Tower configuration, the network, and the controller Tower configuration are combined, the SCIT system design is produced. This design is shown in Figure 7.

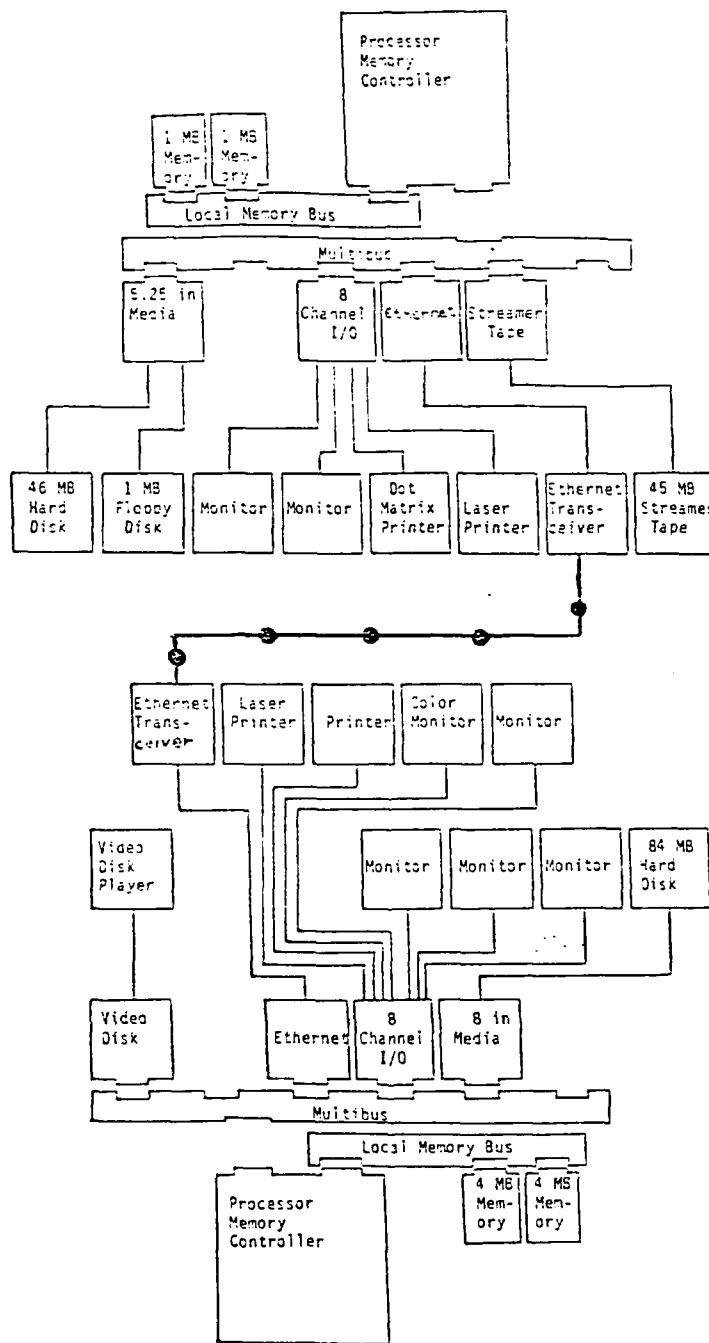


Figure 7. Proposed SCIT System Computer Hardware Design

Although cost was removed as a criteria, some mention needs to be made of the approximate system cost. An exact cost cannot be made in this document due to the specific requirements of system procurement regulations. The hardware cost for the SCIT system proposed in this chapter should be between \$80,000 and \$100,000 exclusive of system software development cost. This cost is based on current (July 1985) commercial cost for the equipment involved.

## V. Recommendations and Conclusion

### Recommendations

The recommendations provided are divided into four separate sections. The first section gives recommendations on the personnel needed to implement the SCIT system. The second section gives recommendations on how to proceed with the actual hardware development, while the third section is concerned with the software development for the system. The final section recommends future actions to be taken once the system is fully operational.

Personnel. There should be two separate teams used for the implementation of the SCIT system. The first team should be computer hardware experts who are familiar with ATFES. This team would be used to implement the hardware design of the system. The second team should be software coding experts who are also familiar with the ATFES software. This team would be used to develop the simulation software needed for the SCIT system. Based on the development of the ETS and BABAS, it is recommended that both teams be made up of personnel who are currently in the military or are Department of Defense (DOD) civilians. This has worked successfully for both the ETS and BABAS, and provides several advantages. These include reduced system development cost, the development of in house systems expertise, and a quicker start time on software development, since Signal Corps familiarity will not need to be established first.

Hardware Implementation. In implementing the hardware design for the SCIT system, it is recommended that the system be assembled in stages. After a suitable location is found with the two separate rooms needed, the Syscon Tower should be established and tested with the ATFES software to insure that it is working correctly. Once it is working correctly, the LAN should be established and the controller Tower connected. The LAN should be tested for proper operation at this time by insuring that all terminals on the controller Tower are able to access and use the ATFES software on the Syscon Tower.

After all monitors are working correctly, the video disk player should be installed. It is recommended that the system implementors coordinate with NCR corporation and with the audio visual laboratory at Fort Gordon to properly install and test the video disk system.

Software Design and Implementation. The software development may proceed on a parallel course with the hardware implementation. It is recommended that initially, statistics be obtained from several Corps and Division Signal Battalions to determine what the most common system and circuit engineering problems are. Based upon these statistics, the software development should proceed. The software should be designed in a modular fashion for ease of design, and so that modules can be tested and corrected as they are designed. This testing should begin as soon as the monitors are installed and operational on the controller Tower. After a minimal number of modules are tested and

working correctly, the entire SCIT system could be tested in operation, with corrections being made as needed.

Once a number of problem simulations are tested, corrected, and available, the system could be put in use, while the software design continues for other modules. This would serve two functions. First, personnel could start being trained, even though the system was not complete. The second reason is that the MICROFIX policy of " USE ---> LEARN ---> DEVELOP " could be implemented. This would take into account user problems, complaints, and suggestions at the earliest opportunity. By exercising this policy, the SCIT system could be in use, while continual development and improvement took place. This would hopefully result in a better system for training personnel.

Future Development. In the currently proposed SCIT system design, only one set of personnel may be trained at a time. Once the hardware and software are both working correctly, consideration should be given to further expansion of the system. Additional Syscon centers, based upon the original design, should be added to the SCIT system network one at a time. There are two limiting factors to the number of centers that may be added. First, as more simulations are run concurrently on the controller Tower, processor time will slow down. A determination will need to be made in the future on how much of a slow down can occur without adversely effecting the training. the second limit is that only 16 I/O terminals may be connected to any one Tower. This puts a

limit on the number of controllers that may operate off of any one Tower. By adding one Syscon center at a time, each new configuration may be tested for speed of operation and use of the controller center. In this manner the optimal design may be achieved.

### Conclusions

This thesis effort set out to solve the problem of training Signal Corps officers in communications network management by designing a computer based simulation system. Several computer systems currently being used either for simulations or as decision making aids, were evaluated against established criteria, and the ATFES system using the Tower microcomputer was selected as the system to form the basis of the simulator design. Although ATFES was the selected system, ideas from other systems were also incorporated. Chief among these ideas was separating the computer simulator from the personnel being trained, so that realism would be maximized. This was completed in chapter four by networking two Tower microcomputers together, and having the controllers use one machine while the personnel being trained used the second.

Additionally, by selecting the Tower microcomputer for the system design, there is room for expansion in the future. This will allow the system to grow and change as new requirements are established, or as new technologies become available. In this way, the system will not already be outmoded when it is initially fielded.

Appendix A: Requirements Analysis for  
the S-3 Section of a Corps  
or Division Signal Battalion

In order to complete a systems requirements analysis for the interactive training system, it was first necessary to complete a requirements analysis for the operations section of a Corps or Division Signal Battalion. The general guidance for an operations section is not found in any one manual or book. Instead, it is spread among several different sources. These include :

- 1: ARTEP 11-35 - The training and evaluation plan for Division Signal Battalions (5).
- 2: ARTEP 11-415 - The training and evaluation plan for Corps Signal Battalions (6).
- 3: FM 24-1 - The field manual for Combat Communications (9).
- 4: FM 24-16 - The field manual for Communications-Electronics Orders and Records (8).
- 5: FM 24-22 - The field manual for the Communications - Electronics management system (7).

In addition, there are two draft plans which address further requirements for the operations section. These are:

- 6: The Tactical C<sup>3</sup> Operation and Organization Plan (draft) (4).
- 7: The Operational Plan for MSE Systems (4).

After researching these documents, the requirements for the operations sections were separated into four distinct areas of concern. These were: planning, engineering, maintaining/controlling and records/reports. This appendix lists out the requirements by separate area of concern, and indicates the reference that the requirement was taken from.

TABLE VII.

Planning Requirements

<u>REQUIREMENT</u>	1	2	3	<u>SOURCE</u>			6	7
				4	5			
1. Determine personnel and equipment Requirements.	X	X			X			
2. Provide staff coordination for external units.	X	X	X		X			
3. Prepare and disseminate directives via OPORDERS/FRAGORDERS.	X	X		X	X			
4. Allocate circuits.			X					
5. Plan traffic routes.			X					
6. Layout communications networks.					X			
a. Site locations					X			
b. Antenna orientations					X			
c. Distribution of access points.					X			
7. Assignment of assets and responsibilities.								X
8. Establish and maintain a system of priorities.	X	X			X			
9. Logistics coordination.	X	X						
10. Database preparation.								X

TABLE VIII

Engineering Requirements

<u>REQUIREMENT</u>	1	2	<u>SOURCE</u>		5	6	7
			3	4			
1. Supervise and coordinate the installation of the communications system							
a. Radio	X	X					
b. Multichannel	X	X					
c. RATT	X	X					
2. Supervise activation of the system.							X
3. Transmission link activation.							X
4. Frequency Management.							X

TABLE IX

Maintaining/Controlling Requirements

<u>REQUIREMENT</u>	1	2	<u>SOURCE</u>		5	6	7
			3	4			
1. Changes to the network.	X	X					
a. Rerouting circuits	X	X					
b. Signal center displacement.			X				
c. Route changes						X	
d. Reallocate resources						X	
e. Outages causing network changes.						X	
2. Contingency planning.					X		
a. Redeployment of resources.							X
b. Continual tactical update.	X	X					
c. Equipment destroyed.	X	X					
3. Trunking management.							X

TABLE X

Records/Reports Required

<u>REQUIREMENT</u>	1	2	<u>SOURCE</u>				6	7
			3	4	5			
1. OPORD/FRAGORD	X	X			X			
2. Resource Status Report	X	X			X			
3. NBC Reports	X	X						
4. Circuit Records			X					
5. System Records			X	X	X	X	X	
6. Traffic Data/ Volume Records				X	X			
7. Equipment Status Records				X	X	X		
8. Equipment Performance Records				X	X	X		
9. System/Circuit Quality				X	X			
10. Critical Events Log							X	
11. Personnel Reports				X				

Appendix B: A Statistical Analysis of  
the Rankings of the  
SCIT System Criteria

When LTC Bowser, Maj Zapka, Cpt Woffinden and Cpt Hall were originally asked to weight the systems criteria in order of importance, there was some concern as to the validity of a group weighting. This was due to the different backgrounds of the personnel involved. As a result of this, statistics were taken of the rankings to include the means and standard deviations. Statistics were taken based on the group as a whole originally, and later based upon the "Engineer group" ( Maj Zapka, Cpt Woffinden, and Cpt Hall) to determine the validity of the different rankings.

Table XI shows the group ranking with all criteria listed. The criteria were rank ordered by their mean calculations. It should be noted that only four of the criteria have standard deviations that are under 2.00. These include: speed (rank 1), commercial software availability (rank 13), other simulation software capability (rank 14), and security capability (rank 15). In other words, all personnel regarded the top ranked criteria as fairly important, and the bottom three criteria as relatively unimportant.

TABLE XI

Group Rankings With All Criteria Included

CRITERIA	LTC BOWSER	CPT HALL	MAJ ZAPKA	CPT WOFFINDEN	MEAN	STD DEV	RANK
SPEED:	2	3	4	4	3.25	.96	1
EXPANDABILITY:	7	1	2	5	3.75	2.75	2
NETWORKING CAPABILITY:	10	2	3	2	4.25	3.86	3
DIGITAL TERRAIN CAPABILITY:	6	4	6	7	5.75	1.26	4
GRAPHICS CAPABILITY:	8	5	5	6	6.00	1.41	5
INPUT/OUTPUT CAPABILITIES:	1	11	12	3	6.75	5.56	6
COST:	15	10	1	1	6.75	6.94	7
INTERNAL MEMORY:	3	8	9	9	7.25	2.87	8
MAP STORAGE:	5	6	8	12	7.75	3.09	9
ON LINE MEMORY:	4	9	10	10	8.25	2.87	10
SIGNAL DATABASE SOFTWARE:	13	7	7	8	8.75	2.87	11
OFF LINE MEMORY:	9	12	11	11	10.75	1.25	12
COMMERCIAL SOFTWARE AVAILABILITY:	12	13	13	14	13.00	.82	13
OTHER SIMULATION SOFTWARE CAPABILITY:	14	14	14	13	13.75	.50	14
SECURITY CAPABILITY:	11	15	15	15	14.00	2.00	15

As stated in Chapter 2, cost was removed as a factor since LTC Bowser, the thesis Sponsor, ranked it last. So if we remove cost from the statistical consideration, there are

some changes in the ratings. Now, three of the top five criteria have Standard deviations under 2.00, and the bottom four criteria have standard deviations under 2.00, Table XII reflects these changes.

TABLE XII

Group Criteria Rankings With Cost Removed as a Factor

CRITERIA	LTC BOWSER	CPT HALL	MAJ ZAPKA	CPT WOFFINDEN	MEAN	STD DEV	RANK
SPEED:	2	3	3	3	2.75	.50	1
EXPANDABILITY:	7	1	1	4	3.25	2.37	2
NETWORKING CAPABILITY:	10	2	2	1	3.75	4.19	3
DIGITAL TERRAIN CAPABILITY:	6	4	5	6	5.25	.96	4
GRAPHICS CAPABILITY:	8	5	4	5	5.50	1.73	5
INPUT/OUTPUT CAPABILITIES:	1	10	11	2	6.00	5.23	6
COST:	-----						
INTERNAL MEMORY:	3	8	8	8	6.75	2.50	7
MAP STORAGE:	5	6	7	11	7.25	2.63	8
ON LINE MEMORY:	4	9	9	9	7.75	2.50	9
SIGNAL DATABASE SOFTWARE:	13	7	6	7	8.25	3.20	10
OFF LINE MEMORY:	9	11	10	10	10.00	.82	11
COMMERCIAL SOFTWARE AVAILABILITY:	12	12	12	13	12.25	.50	12
OTHER SIMULATION SOFTWARE CAPABILITY:	14	13	13	12	13.00	.82	13
SECURITY CAPABILITY:	11	14	14	14	13.25	1.50	14

Although removing cost allowed seven out of fourteen of the criteria to have standard deviations under 2.00, there was still a spread within the rankings of the other criteria. Due to this spread, it was decided to rank the criteria using the "Engineer rankings" only, and then observe the statistical breakdown. Table XIII reflects this ranking. In this case, all but two criteria have standard deviations under 2.00, and all but three criteria have standard deviations of 1.00 or under. This similarities in rankings should be expected, since all three personnel have electrical engineering or computer science backgrounds.

After consideration, it was decided in chapter 3 to use four different methods of weighting the scores from the evaluated systems. The first would be with no weightings given. In other words, just use the raw scores. The second method was to use just LTC Bowser's rankings to weight the system criteria from the user's perspective, without any specific computer knowledge. The third method was to use the engineer ranking in order to evaluate the systems from a more technical standpoint. Finally, a group ranking was used as a balance between the second and third rankings. As it turned out, all four methods of ranking selected the ATFES Tower microcomputer as the optimal system.

TABLE XIII

The Engineer Ranking with Cost Removed as a Criteria

CRITERIA	CPT HALL	MAJ ZAPKA	CPT WOFFINDEN	MEAN	STD DEV	RANK
SPEED:	3	3	3	3.00	.00	3
EXPANDABILITY:	1	1	4	2.00	1.73	2
NETWORKING CAPABILITY:	2	2	1	1.67	.58	1
DIGITAL TERRAIN CAPABILITY:	4	5	6	5.00	1.00	5
GRAPHICS CAPABILITY:	5	4	5	4.67	.58	4
INPUT/OUTPUT CAPABILITIES:	10	11	2	7.67	4.93	7
COST:	-----					
INTERNAL MEMORY:	8	8	8	8.00	.00	8
MAP STORAGE:	6	7	11	8.00	2.65	9
ON LINE MEMORY:	9	9	9	9.00	.00	10
SIGNAL DATABASE SOFTWARE:	7	6	7	6.67	.58	6
OFF LINE MEMORY:	11	10	10	10.33	.58	11
COMMERCIAL SOFTWARE AVAILABILITY:	12	12	13	12.33	.58	12
OTHER SIMULATION SOFTWARE CAPABILITY:	13	13	12	12.67	.58	13
SECURITY CAPABILITY:	14	14	14	14.00	.00	14

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### Abstract

This research effort makes a recommendation for the hardware design of a microcomputer based simulation system for the training of US Army Signal Corps officers in communications network management. In order to do this, the first step was to establish the requirements for communications network management in a Signal Battalion S-3 section, and based upon these requirements, establish the criteria for the simulation system.

Once the criteria were established, several computer systems currently in use in the Armed Forces as simulators or as decision making aids, were rated against the criteria. Because of these ratings, the Army Tactical Frequency Engineering System (ATFES), with the Tower microcomputer, was selected for further study as the system the simulator design would be based upon.

The system designed consisted of two networked Tower microcomputers, with the persons being trained using one, and the exercise controllers using the second. As a result of this design, the personnel being trained appear to be in an actual operations environment, and do not have any direct contact with the computer simulations. All simulations are given to the students through the controllers. In this manner, the realism is increased for the students, and a more effective training environment is established.

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